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# UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity)

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No.  
A0000001-04-CWATotal Pages in this Submission  
58

## TO THE ASSISTANT COMMISSIONER FOR PATENTS

Box Patent Application  
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

MULTIPLE MICRO-BLADE HAIR REMOVAL DEVICES AND METHODS FOR MANUFACTURING

and invented by:

ORLOFF, Glennis J.  
BALISTEE, BrianIf a **CONTINUATION APPLICATION**, check appropriate box and supply the requisite information:☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No.: \_\_\_\_\_

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Enclosed are:

## Application Elements

1. ☒ Filing fee as calculated and transmitted as described below
2. ☒ Specification having 43 pages and including the following:
  - a. ☒ Descriptive Title of the Invention
  - b. ☐ Cross References to Related Applications (if applicable)
  - c. ☐ Statement Regarding Federally-sponsored Research/Development (if applicable)
  - d. ☐ Reference to Microfiche Appendix (if applicable)
  - e. ☒ Background of the Invention
  - f. ☒ Brief Summary of the Invention
  - g. ☒ Brief Description of the Drawings (if drawings filed)
  - h. ☒ Detailed Description
  - i. ☒ Claim(s) as Classified Below
  - j. ☒ Abstract of the Disclosure

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58

## Application Elements (Continued)

3. ☒ Drawing(s) (when necessary as prescribed by 35 USC 113)
- a. ☒ Formal                      Number of Sheets                      14
- b. ☐ Informal                      Number of Sheets                      \_\_\_\_\_
4. ☐ Oath or Declaration
- a. ☐ Newly executed (original or copy)                      ☐ Unexecuted
- b. ☐ Copy from a prior application (37 CFR 1.63(d)) (for continuation/divisional application only)
- c. ☐ With Power of Attorney                      ☐ Without Power of Attorney
- d. ☐ DELETION OF INVENTOR(S)  
Signed statement attached deleting inventor(s) named in the prior application,  
see 37 C.F.R. 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation By Reference (usable if Box 4b is checked)  
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under  
Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby  
incorporated by reference therein.
6. ☐ Computer Program in Microfiche (Appendix)
7. ☐ Nucleotide and/or Amino Acid Sequence Submission (if applicable, all must be included)
- a. ☐ Paper Copy
- b. ☐ Computer Readable Copy (identical to computer copy)
- c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

## Accompanying Application Parts

8. ☐ Assignment Papers (cover sheet & document(s))
9. ☐ 37 CFR 3.73(B) Statement (when there is an assignee)
10. ☐ English Translation Document (if applicable)
11. ☐ Information Disclosure Statement/PTO-1449                      ☐ Copies of IDS Citations
12. ☐ Preliminary Amendment
13. ☒ Acknowledgment postcard
14. ☒ Certificate of Mailing

☐ First Class    ☒ Express Mail (Specify Label No.): EK968566204US

# UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity)

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No.  
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58

## Accompanying Application Parts (Continued)

15. ☐ Certified Copy of Priority Document(s) (if foreign priority is claimed)

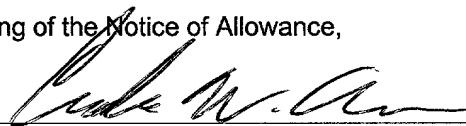
16. ☐ Additional Enclosures (please identify below):

## Fee Calculation and Transmittal

### CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	115	- 20 =	95	x \$18.00	\$1,710.00
Indep. Claims	5	- 3 =	2	x \$78.00	\$156.00
Multiple Dependent Claims (check if applicable) <input type="checkbox"/>					\$0.00
BASIC FEE					\$690.00
OTHER FEE (specify purpose)					\$0.00
TOTAL FILING FEE					\$2,556.00

- ☐ A check in the amount of \_\_\_\_\_ to cover the filing fee is enclosed.
- ☒ The Commissioner is hereby authorized to charge and credit Deposit Account No. 23-0456 as described below. A duplicate copy of this sheet is enclosed.
- ☒ Charge the amount of \$2,556.00 as filing fee.
- ☒ Credit any overpayment.
- ☒ Charge any additional filing fees required under 37 C.F.R. 1.16 and 1.17.
- ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

  
Signature

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**CERTIFICATE OF MAILING BY "EXPRESS MAIL" (37 CFR 1.10)**Applicant(s): **Glennis J. Orloff, et al.**

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Examiner

**Not yet assigned**

Group Art Unit

**Not yet assigned**Invention: **MULTIPLE MICRO-BLADE HAIR REMOVAL DEVICES AND METHODS FOR MANUFACTURING**I hereby certify that this Utility Patent Application Transmittal*(Identify type of correspondence)*

is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under  
37 CFR 1.10 in an envelope addressed to: The Commissioner of Patents and Trademarks, Washington, D.C.

20231-0001 on July 28, 2000*(Date)***Christine Cicensia***(Typed or Printed Name of Person Mailing Correspondence)*  
*(Signature of Person Mailing Correspondence)***EK968566204US***("Express Mail" Mailing Label Number)***Note: Each paper must have its own certificate of mailing.**

**UNITED STATES PATENT APPLICATION**  
**FOR**  
**MULTIPLE MICRO-BLADE REMOVAL DEVICES**  
**AND METHODS FOR MANUFACTURING**  
**OF**  
**GLENNIS J. ORLOFF AND BRIAN BALISTEE**

00000001-04-CWA

MULTIPLE MICRO-BLADE HAIR REMOVAL  
DEVICES AND METHODS FOR MANUFACTURING

The present invention is directed to devices used for shaving, and more particularly, to hair removal devices comprising a plurality of micro-blades and methods of manufacturing such hair removal devices.

BACKGROUND

Complete hair removal with a shaving device requires that the blades encounter the hair being removed. In attempts to increase the probability of such an encounter, prior art includes devices that conform to body contours and/or have an increased number of cutting surfaces.

For example, US Patent 5,205,040 discloses a shaving cloth wherein a cloth-like or flexible material is used to secure a plurality of individual cutting heads, whereby the cutting heads and their corresponding edges are randomly oriented. When in use the flexible material securing the individual cutting heads contours the body surface.

US Patent 5,088,195 discloses a blade member with multiple cutting surfaces. The blade member is a metal film deformed in

such a way as to form apertures extending above the shave plane. These apertures are subsequently sharpened forming a metal film with a plurality of sharpened apertures. When engaged with the skin, one or more of these sharpened apertures contact one or more hairs and thus cut the hair.

#### SUMMARY OF THE INVENTION

Various embodiments of the present invention comprise hair removal devices comprising a plurality of micro-blades and methods for their fabrication, including, for example, microelectronic manufacturing techniques. Embodiments of the present invention preferably have many "blades" capable of removing hair. As used herein, the term "blades" is not limited to strips of metal such as stainless steel which are ground and honed to a sharp edge, but includes metals, non-metals, ceramics, semiconductor, and polymeric materials which are preformed and subsequently sharpened or are initially formed with a thickness suitable for cutting hair. The micro-blades can also be formed from multiple layers which have a cumulative thickness suitable for cutting hair or wherein one or more of the layers are subsequently removed leaving a rigid or semi-rigid edge with a thickness suitable for cutting hair. Preferred "blades" of the present invention preferably have at least one edge with a radii of curvature not greater than about

1000 angstroms, preferably not greater than about 500 angstroms, more preferably not greater than about 250 angstroms. Alternative embodiments of the present invention comprise a relatively high number of abrasion elements for hair removal. In addition to blades and/or abrasion elements, shaving devices of the present invention can comprise skin flow control elements which are not designed to cut hair but which serve to control the flow of hair across the shaving device and thereby control the angle at which the blade edges or abrasion elements contact the hair.

Another aspect of the present invention comprises blades having a cutting depth which are much smaller than that of previously known shaving devices. As used herein, the term "cutting depth" is used to indicate the portion of the blade edge which can travel unobstructed through a hair. Since hair typically comprises a diameter of about 75 microns, the cutting depth of previously known shaving elements has been substantially greater than 75 microns to enable the cutting edge to cut entirely through the hair in a single stroke. According to some embodiments of the present invention, the cutting depth of one or more blades is not greater than about 75 microns, or is even less.







Figures 3 and 4 are top and side views of a second blade of the present invention.

Figures 5 and 6 are side views and top, perspective views, respectively, of a straight blade of the present invention.

Figures 7 and 8 are top and perspective views, respectively, of an abrasive element of the present invention.

Figures 9 and 10 are side and top views, respectively, of an alternative blade and blade support of the present invention.

Figures 11 and 12 are side and top views, respectively, of another blade of the present invention.

Figures 13 and 14 are side and top views, respectively, of a further embodiment of a blade of the present invention.

Figures 15 and 16 are side and top views, respectively, of a further embodiment of the present invention.

Figures 17 and 18 are side and top views, respectively, of a further embodiment of the present invention.

Figures 19 and 20 are side and top views, respectively, of a further embodiment of the present invention.

Figure 21 is a top view of one embodiment of the present invention showing multiple elements like the ones shown in Figures 1 and 2 arranged.

Figure 22 is a side view of the embodiment illustrated in Figure 21.

Figures 23 and 24 are top and side views, respectively, of an alternative embodiment of the present invention.

Figures 25 and 26 are top and side views, respectively, of an alternative embodiment of the present invention.

Figures 27 and 28 are side and top views of a serrated blade of one embodiment of the present invention.

Figures 29 and 30 are side and top, perspective views, respectively, of another embodiment of the present invention showing an arrangement of multiple elements like those shown in figure 28 which may or may not have serration.

Figures 31 and 32 are side and perspective views, respectively, of another embodiment of the present invention.

Figures 33 and 34 are side and perspective views, respectively, of another blade arrangement of the present invention.

Figures 35 and 36 are top and side views, respectively, of a further embodiment of the present invention showing one possible arrangement of multiple elements like those shown in Figures 3 and 4.

Figures 37 and 38 are top and cross-sectional side views, respectively, of a further embodiment of the present invention.

Figures 39 - 42 illustrate different abrasive elements of embodiments of the present invention.

#### DETAILED DESCRIPTION

The various embodiments of the present invention comprise novel shaving devices and methods for forming shaving devices. One aspect of the present invention comprises the use of a relatively

large number of micro-blades. As used herein, the term "micro-blades" is used to indicate blades comprising at least one edge having a radii of curvature not greater than about 1000 angstroms, preferably not greater than about 500 angstroms, and more preferable not greater than 250 angstroms, or which comprise a cutting depth of not greater than about 1000 microns. As described in further detail below, hair removal devices of the present invention can comprise hundreds of blades having cutting edges oriented in one or more directions.

One aspect of the present invention comprises the use of micro-blades, preferably a high number of micro-blades, either alone or in combination with other skin engaging elements and/or abrasive elements. Figures 1 and 2 are side and top views, respectively, of one micro-blade unit 10 which comprises a blade support 12, a blade 14 having a cutting edge 15 and a cutting edge support 16. The various illustrations shown herein are intended to be illustrative of portions of shaving devices and not entire shaving devices of the present invention. This illustrated blade 14 and blade edge 15 are extremely thin and therefore are capable of cutting hair when drawn across a skin surface in any direction. The bottom of blade support 12 is preferably formed from a substrate (shown in phantom) which is most preferably flexible.



invention can be achieved with much greater cutting depths. The use of these relatively small cutting depths is one aspect of the present invention and is not necessary for all embodiments.

The shape of the micro-blade shown in Figures 1 and 2 is round. The micro-blades of the present invention are not limited to any specific shape and can have, for example, curved or straight surfaces. For example, the present invention can also be practiced using micro-blades which are hexagonal, triangular, rectangular, or any other geometric shape desired.

A plurality of structures such as those shown in Figures 1 and 2 can be arranged in various patterns, such as, but not limited to that shown in Figures 21 and 22. The micro-blade structures are preferably generated simultaneously using standard microelectronic manufacturing techniques. One possible sequence of steps to form such structures includes starting with a substrate made of polyimide, polyetheretherketone (PEEK), other flexible materials alone or in combination, with a thickness of about 0.05 mm to 2 mm, preferably with a thickness of about 0.1 mm to 0.5 mm. A thin film of tungsten, tantalum nitride, boron nitride, diamond, or any other desired blade material is subsequently deposited onto the substrate. The desired film thickness is dependent on the blade





in Figure 1 has been eliminated and the blade edge has been formed by etching a thick film leaving an angular cutting edge 55. Etching of the blade edge can be accomplished using either wet or dry etching techniques. In this embodiment, the support element is not required due to the overall thickness of the blade element 54 whose material strength well exceeds the force required to cut a hair.

Figures 3 and 4 illustrate an alternative micro-blade unit 20 of the present invention wherein an aperture is provided internally of the sharpened cutting edge 25 of blades 24. These micro-blades comprise a base 22 which is formed on a substrate 21 by film deposition techniques. These micro-blade units 20 will only cut hair which is forced into the aperture defined by circular blade edge 25.

The shape of the micro structures shown in Figures 3 and 4 is round; however, those who are knowledgeable in the art would realize this is only one of many shapes one could generate. Micro structure shapes may include but are not limited to hexagonal, triangular, rectangular, or any other geometric shape.



structure is removed using appropriate dry etch or wet etch techniques leaving the blade structure as illustrated in Figures 3 and 4.

Figures 5 and 6 illustrate a substantially linear micro-blade of another embodiment of the present invention. Figure 5 is a side view illustrating blade 30 having a cutting edge 35 extending from a substrate (shown in phantom) at an angle. Figure 6 illustrates the cutting edge 35 of this linear blade. The blades in this embodiment of the present invention can be oriented in the same or different directions as they extend upwardly at some angle relative to the substrate.

A plurality of structures such as those shown in Figures 5 and 6 and arranged in a pattern such as, but not limited to, that shown in Figures 29 and 30 are generated simultaneously using standard microelectronic manufacturing techniques. One possible sequence of steps to form such structures includes starting with a substrate made of polyimide, polyetheretherketone (PEEK), or other flexible material with a thickness ranging from 0.05 mm to 2 mm, preferably with a thickness range of 0.1 mm to 0.5 mm. One or more films are deposited onto the substrate. The deposited films can consist of tungsten, tantalum nitride, boron nitride, diamond, or any other

desired blade material. The desired film thickness is about 10 microns to 1000 microns, preferably with a thickness range of about 100 microns to 300 microns. To form the structures, the film stack consisting of the substrate and deposited films is patterned using photolithography techniques. The deposited films as well as the substrate are subsequently selectively etched, preferably with the substrate angled with respect to the etch source, with techniques that include but are not limited to ion milling, sputtering, reactive ion etching, and electron cyclotron resonance etching.

Figures 7 and 8 illustrate an abrasive element of one embodiment of the present invention having a generally pyramidal shape. Figure 7 is a top view showing four generally triangular sides 41-44. Figure 8 is a perspective view. This illustrated abrasive element and other abrasive elements of the present invention are preferably formed of hard materials, such as those described above for forming blades and function like sandpaper to abrade the hair away leaving the edges of hair frayed and resulting in a smooth feel. The abrasive elements of the present invention can take different forms such as those shown in Figures 39 through 42.

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A plurality of structures such as those shown in Figures 7, 8, and 39 through 42 can be arranged in a pattern and generated simultaneously using standard microelectronic manufacturing techniques. One possible sequence of steps to form such structures includes starting with a substrate made of polyimide, polyetheretherketone (PEEK), or other flexible material with a thickness ranging from 0.05 mm to 2 mm, preferably with a thickness range of 0.1 mm to 0.5 mm. One or more films are deposited onto the substrate. The deposited films can consist of tungsten, tantalum nitride, boron nitride, diamond, or any other desired abrasive material. The desired film thickness is about 2 microns to 55 microns, preferably with a thickness of about 20 microns to 30 microns. To form the structures, the film stack consisting of the substrate and deposited films is patterned using photolithography techniques and the deposited films are selectively etched with techniques that include but are not limited to ion milling, sputtering, reactive ion etching, and electron cyclotron resonance etching. Although it may be preferred for the abrasive elements to exhibit a sharper peak at the top of the structure, current microelectronic manufacturing techniques known to the present inventors do not make the formation of such a structure possible. Advantages are also gained by not having a sharp peak on

top of the abrasive structures by limiting the incidence of skin abrasion.

Figures 11 and 12 illustrate a further embodiment of the present invention wherein the blade edge of a micro-blade unit similar to those shown in Figures 1, 2, 9 and 10 comprises a plurality of segments. Although Figures 11 and 12 show an eight-pointed star-shaped blade when viewed from above, there can be any number of segments by a blade structure without departing from the scope of the present invention. While this illustrated embodiment shows substantially linear sharpened edges, the edges can also be curved, scalloped or serrated having a plurality of curved, cutting edges.

Figures 13 through 16 illustrate two additional embodiments of the present invention wherein generally circular micro-blades have two circular cutting edges, a first formed internally and a second formed externally. The embodiments shown in Figures 13 and 14 comprise thin film edges 75 and 76 supported by a donut shaped blade support 72. An upper blade support 77 helps to maintain the blade on blade support 72. The embodiment illustrated in Figures 15 and 16 comprises etched external edges 85 and internal edges 86 mounted on a blade support 82. These double edged micro-blade

units advantageously provide cutting action when drawn in any direction across a skin surface being shaved. Although not shown, these edges can be serrated, scalloped or shaped.

Two additional embodiments of the present invention are shown in Figures 17 through 20. These embodiments comprise only internal cutting edges. The embodiments shown in Figures 17 and 18 comprise a single thin film edge 96 located interiorly of the blade and the embodiment illustrated in Figures 19 and 20 comprises an etched interior edge 106. Although not shown, these edges can also be serrated, scalloped or shaped.

The micro-blades, abrasive elements, and/or non-cutting, non-abrasive skin engaging elements of the present invention can be positioned in any manner desired on a substrate. Figures 21 and 22 illustrate micro-blades of the type illustrated in Figures 1 and 2 positioned in slightly offset rows on a flexible substrate 110. These blade units are positioned in spaced arrangement. Blade unit spacing is preferably about 75 microns to 1500 microns with a more preferred range of about 200 microns to 800 microns. Figures 23 and 24 are top and side views of an alternative embodiment of the present invention wherein blade units are surrounded by a non-



cutting structure 18 in order to direct and enhance skin flow during hair removal.

As stated above, one or more skin engaging elements which are not designed to abrade or cut hair can also be positioned around, between, or amongst micro-blades or abrasive elements of the present invention. These skin engaging elements provide a function similar to a conventional guard bar in that they are designed to stretch the skin and/or optimize the flow of skin and hair toward one or more cutting edges. Additionally, they can provide support by restricting a flexible blade from collapsing into another skin engaging element, by improving the hair capturing capability of the sharpened blade edge and/or by providing desirable tactile sensations during hair removal.

Figures 25 and 26 are top and side views, respectively, of an embodiment of the present invention comprising truncated skin engaging elements 135 which are positioned in rows between micro-blade units 10. The skin engaging elements of the present invention are preferably formed of a resilient material, such as those materials described above which can be used to form a flexible substrate. The skin engaging elements can be used with micro-blades, with abrasion element such as those shown in Figures

7 and 39 to 42, or with both micro-blades and abrasive elements. In order to facilitate manufacture, the skin engaging elements 135 can be identical to the blade supports 12 but are not provided with an actual blade. While this illustrated embodiment shows offset rows of micro-blade units 10 and skin engaging elements 135, the arrangement of the blades and skin engaging elements can be staggered and need not form rows.

Figures 27 and 28 show an embodiment of the present invention similar to that shown in Figures 5 and 6, however, the cutting edge 145 of each blade is serrated, instead of linear.

Figures 29 and 30 show one method of arranging a plurality of linear micro-blades 30 having cutting edges 35 of one embodiment of the present invention on a substrate 150. In this embodiment, the blade edge directions are aligned and faced in a single direction. In the embodiment shown in Figures 31 and 32, the blade edges are crossed having one set of blades facing one direction and another set of blades facing another.

The embodiment shown in Figures 33 and 34 shows alternating blade edges facing into different directions. From the present description it will also be appreciated by those skilled in the art

that these or other micro-blades can be angled in one, two or even more directions to provide multi-directional shaving action.

Figures 37 and 38 are top and cross-sectional side views, respectively, of another embodiment of micro-blades of the present invention. These illustrated micro-blades are mounted on a substrate 180 and comprise micro-blade supports 185 upon which are deposited micro-blade edges 186 and upper blade supports 188. The upper blade supports 188 are designed to provide greater support to the micro-blade edges 186. During the deposition of upper blade supports 188, some of the upper blade support material 189 may enter the interior portion of blade support 185 if that region is not covered during the deposition of this upper blade support material. In accordance with this and other embodiments of the present invention, upper blade support material 188 can also be used to provide a degree of skin flow control if desired.

The various embodiments of the present invention are preferably formed by manufacturing techniques which have been previously known in the area of microelectronics such as integrated circuits and printed circuit boards. These manufacturing techniques are capable of providing significantly sharper cutting edges than the blades manufactured using standard grinding and

honing techniques. It is believed that these blades will minimize the effort required to cut each hair.

Such techniques can include photolithography for patterning, dry plasma and wet chemical etches for material removal and plasma depositions for material application.

The substrates of the present invention can generally be in the form of a towelette or can be formed as a razor head on a permanent handle or on a disposable handle. As used herein, the term "razor head" is meant to include cartridges adapted to be connected to a separate razor as well as the operative cutting portion of a disposable razor wherein the handle and cutting portion are formed as a single unit. The substrates of the present invention can be flexible or rigid. The techniques of the present invention can be utilized to provide many blades, abrasive elements and skin engaging elements. For example, according to the present invention, hair removal device can comprise at least ten, fifty, one hundred, two hundred, five hundred or even at least about one thousand micro-blades.

One particular type of substrate may comprise a polyimide. The blades can be arranged on the substrate, randomly, in staggered

rows, in ordered rows and columns or in any other desired arrangement.

# CLAIMS

1. A personal hair removal device comprising:  
a substrate;  
a plurality of blades connected to said substrate, each of said blades comprising at least one cutting edge with a radius of curvature not greater than about 1000 angstroms.
2. A hair removal device according to claim 1 wherein said radius of curvature is not greater than about 500 angstroms.
3. A hair removal device according to claim 1 wherein said radius of curvature is not greater than about 250 angstroms.
4. A hair removal device according to claim 1 wherein said radius of curvature is not greater than about 75 angstroms.
5. A hair removal device according to claim 1 wherein said radius of curvature is not greater than about 50 angstroms.
6. A hair removal device according to claim 1 wherein said radius of curvature is not greater than about 30 angstroms.

7. A hair removal device according to claim 1 wherein said radius of curvature is not greater than about 10 angstroms.
8. A hair removal device according to claim 1 comprising at least about 10 blades.
9. A hair removal device according to claim 1 comprising at least about 50 blades.
10. A hair removal device according to claim 1 comprising at least about 100 blades.
11. A hair removal device according to claim 1 comprising at least about 200 blades.
12. A hair removal device according to claim 1 comprising at least about 500 blades.
13. A hair removal device according to claim 1 comprising at least about 1000 blades.

14. A hair removal device according to claim 1 wherein said blades comprise a cutting depth of not greater than about 1000 microns.
15. A hair removal device according to claim 1 wherein said blades comprise a cutting depth of not greater than about 500 microns.
16. A hair removal device according to claim 1 wherein said blades comprise a cutting depth of not greater than about 250 microns.
17. A hair removal device according to claim 1 wherein said blades comprise a cutting depth of not greater than about 100 microns.
18. A hair removal device according to claim 1 wherein said blades comprise a cutting depth of not greater than about 75 microns.
19. A hair removal device according to claim 1 wherein said blades comprise a cutting depth of not greater than about 50 microns.



20. A hair removal device according to claim 1 wherein said cutting edges are straight.

21. A hair removal device according to claim 1 wherein said cutting edges are serrated.

22. A hair removal device according to claim 1 wherein said cutting edges are curved.

23. A hair removal device according to claim 1 wherein a plurality of said blades are mounted on separate blade supports.

24. A hair removal device according to claim 1 wherein said blades are arranged in ordered columns and rows on said substrate.

25. A hair removal device according to claim 1 wherein said blades are arranged in staggered columns and rows on said substrate.

26. A hair removal device according to claim 1 further comprising at least one guard element comprising a skin engaging surface.

27. A hair removal device according to claim 1 further comprising a plurality of guard elements each comprising at least one skin engaging surface.
28. A hair removal device according to claim 26 wherein said guard element is formed of a resilient material.
29. A hair removal device according to claim 27 wherein at least some of said guard elements are disposed between some of said blades.
30. A hair removal device according to claim 1 wherein at least some of said cutting edges are oriented in different directions.
31. A hair removal device according to claim 1 wherein at least some of said cutting edges are oriented in at least two different directions which are angled at least about 90° to each other.
32. A hair removal device according to claim 1 wherein said substrate is flexible.

33. A hair removal device comprising:

a substrate;

a plurality of blades connected to said substrate,  
wherein said blades comprise a cutting depth of not greater  
than about 1000 microns.

34. A hair removal device according to claim 33 wherein said  
cutting depth is not greater than about 500 microns.

35. A hair removal device according to claim 33 wherein said  
cutting depth is not greater than about 250 microns.

36. A hair removal device according to claim 33 wherein said  
cutting depth is not greater than about 100 microns.

37. A hair removal device according to claim 33 wherein said  
cutting depth is not greater than about 75 microns.

38. A hair removal device according to claim 33 wherein said  
cutting depth is not greater than about 50 microns.

39. A hair removal device according to claim 33 comprising at  
least 10 blades.

40. A hair removal device according to claim 33 comprising at least about 50 blades.
41. A hair removal device according to claim 33 comprising at least about 100 blades.
42. A hair removal device according to claim 33 comprising at least about 200 blades.
43. A hair removal device according to claim 33 comprising at least about 500 blades.
44. A hair removal device according to claim 33 comprising at least about 1000 blades.
45. A hair removal device according to claim 33 wherein said blades comprise a radii of curvature not greater than about 1000 angstroms.
46. A hair removal device according to claim 33 wherein said radii of curvature is not greater than about 500 angstroms.

47. A hair removal device according to claim 33 wherein said radii of curvature is not greater than about 250 angstroms.
48. A hair removal device according to claim 33 wherein said radii of curvature is not greater than about 100 angstroms.
49. A hair removal device according to claim 33 wherein said radii of curvature is not greater than about 50 angstroms.
50. A hair removal device according to claim 33 wherein said radii of curvature is not greater than about 30 angstroms.
51. A hair removal device according to claim 33 wherein said radii of curvature is not greater than about 10 angstroms.
52. A hair removal device according to claim 33 wherein said cutting edges are straight.
53. A hair removal device according to claim 33 wherein said cutting edges are serrated.
54. A hair removal device according to claim 33 wherein said cutting edges are curved.

55. A hair removal device according to claim 33 wherein said blades are mounted on separate blade supports.

56. A hair removal device according to claim 33 wherein said blades are arranged in ordered columns and rows on said substrate.

57. A hair removal device according to claim 33 wherein said blades are arranged in staggered columns and rows on said substrate.

58. A hair removal device according to claim 33 further comprising at least one guard element comprising a skin engaging surface.

59. A hair removal device according to claim 33 further comprising a plurality of guard elements each comprising at least one skin engaging surface.

60. A hair removal device according to claim 33 wherein at least some of said guard elements are disposed between some of said blades.

61. A hair removal device according to claim 33 wherein at least some of said cutting edges are oriented in different directions.
62. A hair removal device according to claim 33 wherein said substrate is flexible.
63. A hair removal device according to claim 33 wherein at least some of said cutting edges are oriented in at least two different directions which are angled at least about 90°.
64. A hair removal device comprising:
  - a substrate;
  - at least 10 micro-blades connected to said substrate.
65. A hair removal device according to claim 64 comprising at least about 50 of said micro-blades.
66. A hair removal device according to claim 64 comprising at least about 100 of said micro-blades.
67. A hair removal device according to claim 64 comprising at least about 200 of said micro-blades.

68. A hair removal device according to claim 64 comprising at least about 500 of said micro-blades.
69. A hair removal device according to claim 64 comprising at least about 1000 of said micro-blades.
70. A hair removal device according to claim 64 wherein said blades comprise a radii of curvature not greater than about 1000 angstroms.
71. A hair removal device according to claim 64 wherein said radii of curvature is not greater than about 500 angstroms.
72. A hair removal device according to claim 64 wherein said radii of curvature is not greater than about 250 angstroms.
73. A hair removal device according to claim 64 wherein said radii of curvature is not greater than about 100 angstroms.
74. A hair removal device according to claim 64 wherein said radii of curvature is not greater than about 50 angstroms.



75. A hair removal device according to claim 64 wherein said radii of curvature is not greater than about 10 angstroms.
76. A hair removal device according to claim 64 wherein said blades comprise a cutting depth of not greater than about 1000 microns.
77. A hair removal device according to claim 64 wherein said blades comprise a cutting depth of not greater than about 500 microns.
78. A hair removal device according to claim 64 wherein said blades comprise a cutting depth of not greater than about 250 microns.
79. A hair removal device according to claim 64 wherein said blades comprise a cutting depth of not greater than about 100 microns.
80. A hair removal device according to claim 64 wherein said blades comprise a cutting depth of not greater than about 75 microns.

81. A hair removal device according to claim 64 wherein said blades comprise a cutting depth of not greater than about 50 microns.
82. A hair removal device according to claim 64 wherein said cutting edges are straight.
83. A hair removal device according to claim 64 wherein said cutting edges are serrated.
84. A hair removal device according to claim 64 wherein said cutting edges are curved.
85. A hair removal device according to claim 64 wherein said blades are each mounted on separate blade supports.
86. A hair removal device according to claim 64 wherein said blades are arranged in ordered columns and rows on said substrate.
87. A hair removal device according to claim 64 wherein said blades are arranged in staggered columns and rows on said substrate.

88. A hair removal device according to claim 64 further comprising at least one guard element comprising a skin engaging surface.
89. A hair removal device according to claim 64 further comprising a plurality of guard elements each comprising at least one skin engaging surface.
90. A hair removal device according to claim 64 wherein at least some of said guard elements are disposed between some of said blades.
91. A hair removal device according to claim 64 wherein at least some of said cutting edges are oriented in different directions.
92. A hair removal device according to claim 64 wherein at least some of said cutting edges are oriented in at least two different directions which are angled at least about 90°.
93. A hair removal device according to claim 64 wherein said substrate is flexible.



99. A method of making a personal hair removal device according to claim 96 further comprising the step of creating a pattern on said deposited film prior to said etching step.
100. A method of making a personal hair removal device according to claim 99 wherein said pattern is created by photolithography.
101. A method of making a personal hair removal device according to claim 96 wherein said step of providing a substrate comprises providing a flexible substrate.
102. A method of making a personal hair removal device according to claim 96 wherein said step of providing a substrate comprises polyimide.
103. A method of making a personal hair removal device according to claim 96 wherein said step of providing a substrate comprises polyetheretherketone (PEEK).
104. A method of making a personal hair removal device according to claim 96 wherein said step of providing a substrate comprises providing a flexible substrate having a thickness of about 0.05 mm to about 2 mm.

105. A method of making a personal hair removal device according to claim 96 wherein said step of providing a substrate comprises providing a flexible substrate having a thickness of about 0.1 mm to about 0.5 mm.
106. A method of making a personal hair removal device according to claim 96 wherein said step of depositing a thin film of etchable material comprises depositing a material selected from the group consisting of tungsten, tantalum nitride, boron nitride, diamond, and combinations thereof.
107. A method of making a personal hair removal device according to claim 96 wherein said depositing step is performed utilizing chemical vapor deposition.
108. A method of making a personal hair removal device according to claim 96 wherein said depositing step is performed utilizing plasma assisted chemical vapor deposition.
109. A method of making a personal hair removal device according to claim 96 wherein said depositing step is performed utilizing electron cyclotron resonance deposition.

110. A method of making a personal hair removal device according to claim 96 wherein said depositing step is performed utilizing sputter deposition.

111. A method of making a personal hair removal device according to claim 96 wherein said depositing step is performed utilizing radio frequency assisted deposition.

112. A method of making a personal hair removal device according to claim 96 wherein said etching step comprises sputtering.

113. A method of making a personal hair removal device according to claim 96 wherein said etching step comprises reactive ion etching.

114. A method of making a personal hair removal device according to claim 96 wherein said etching step comprises ion milling.

115. A method of making a personal hair removal device according to claim 96 wherein said etching step comprises wet chemical etching

## ABSTRACT

Hair removal devices comprising a plurality of micro-blades and methods for their fabrication, include, for example, microelectronic manufacturing techniques. Preferred "blades" have at least one edge with a radius of curvature not greater than about 1000 angstroms, preferably not greater than about 500 angstroms. Alternative embodiments of the present invention comprise a relatively high number of abrasion elements for hair removal. In addition to blades and/or abrasion elements, shaving devices of this invention can comprise skin flow control elements which control the flow of hair across the shaving device and thereby control the angle at which the blade edges or abrasion elements contact the hair.

Another aspect of the present invention comprises blades having cutting depth which are much smaller than previously known shaving devices. For example, the cutting depth of one or more blades is not greater than about 75 microns, or is even less.

Shaving devices are formed on rigid or flexible substrates using one or more of the following techniques: photolithography, wet chemical etching, dry etching, or material deposition techniques.



FIG-1

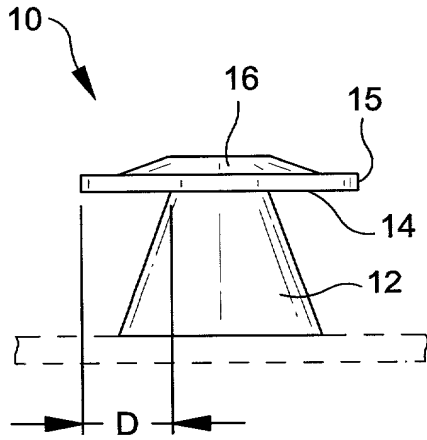


FIG-2

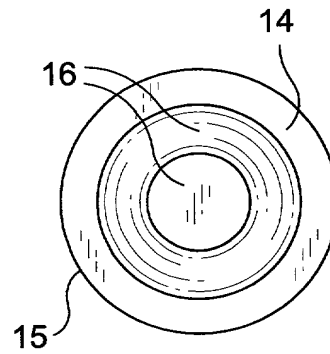


FIG-3

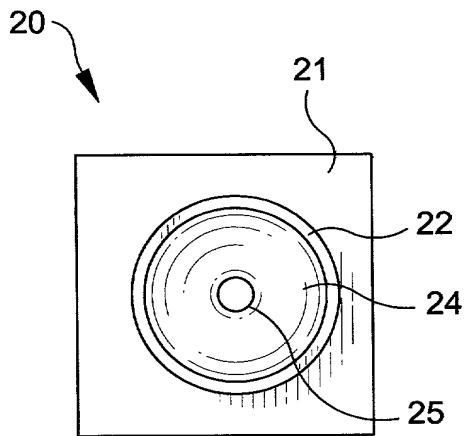


FIG-4

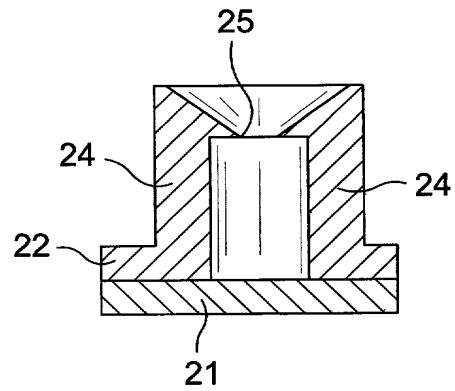


FIG-5

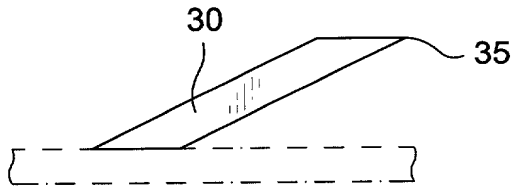


FIG-6

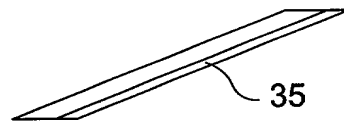


FIG-7

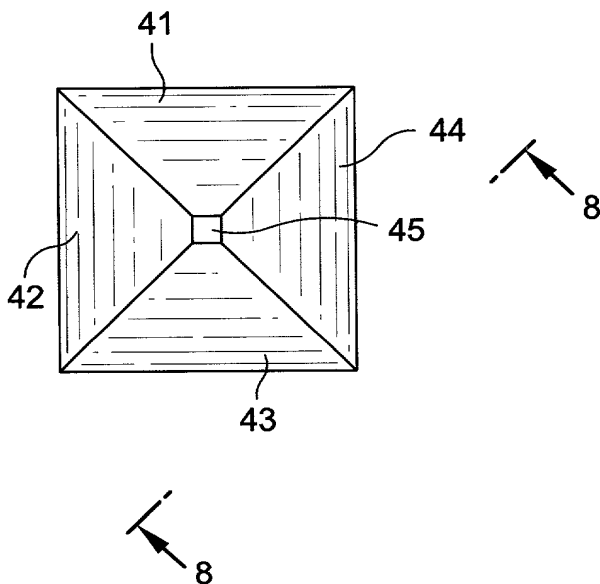


FIG-8

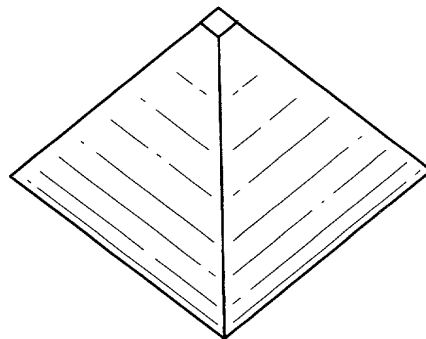


FIG-9

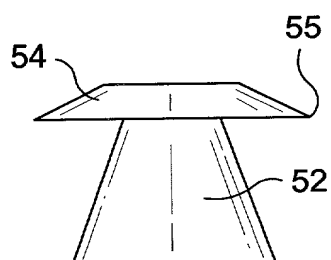


FIG-10

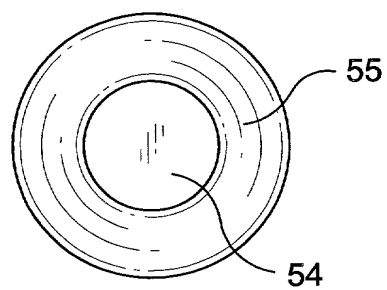


FIG-11

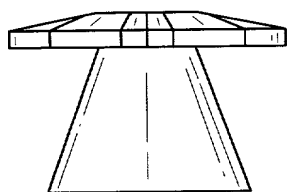


FIG-12

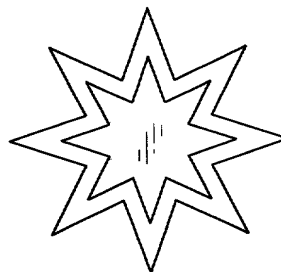


FIG-13

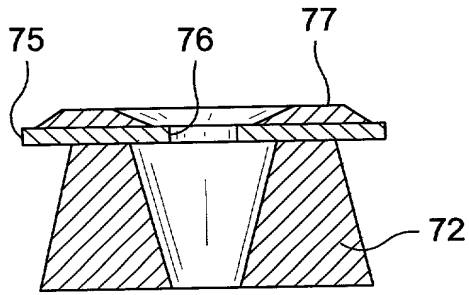


FIG-14

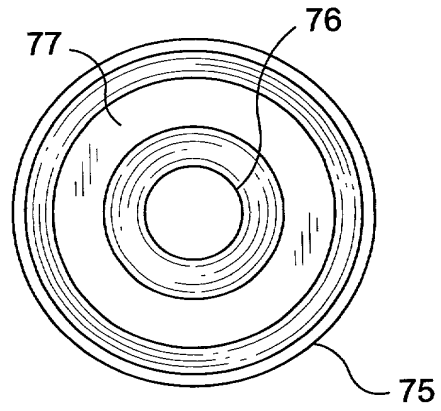


FIG-15

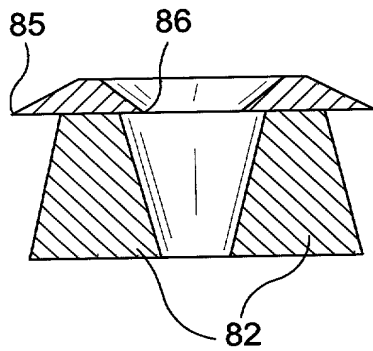


FIG-16

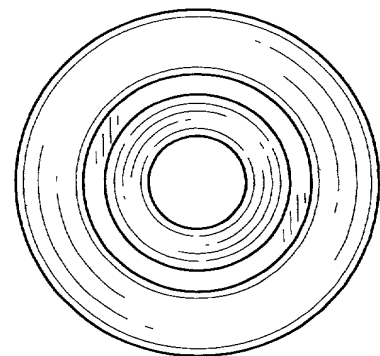


Fig. 10 is a perspective view of the upper part of the mold assembly. It shows the upper mold 96, which is a rectangular block with a central longitudinal slot. The upper mold is supported by two tapered, conical supports. The top surface of the upper mold is indicated by a dashed line, suggesting it is not visible from this perspective.

FIG. 10 is a cross-sectional view of a circular component, likely a lens or mirror, showing concentric rings and a central circular feature. A label '96' points to the outer ring.

This diagram shows a cross-sectional view of a second embodiment of the device. It features a horizontal member 106, which is a plate with a central rectangular opening. Below this plate, there are two trapezoidal support structures. The left support structure is labeled 107 and the right one is labeled 108. Both support structures are filled with diagonal hatching lines. The central opening in the plate 106 is aligned with the gap between the two support structures. A dashed vertical line runs through the center of the opening in the plate and the gap between the supports, indicating a central axis of symmetry.

FIG. 10 is a cross-sectional view of a circular disk. A wavy line labeled 106 points to the inner ring of the disk.

FIG-21

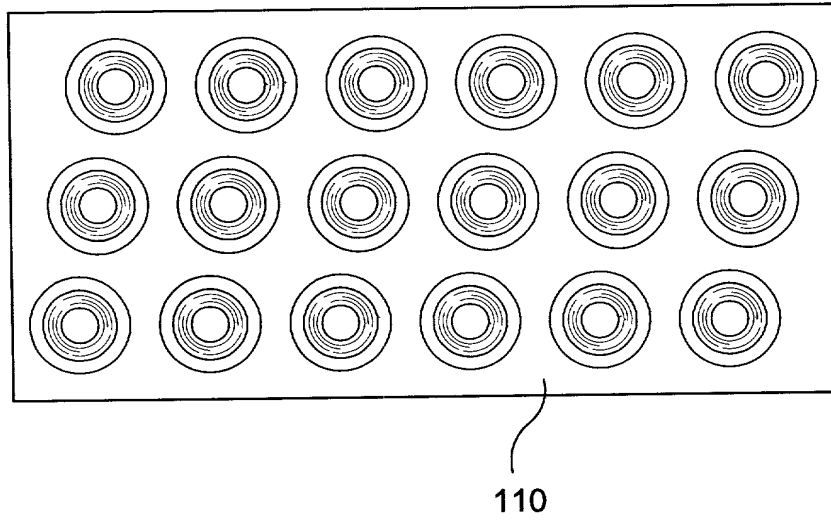


FIG-22

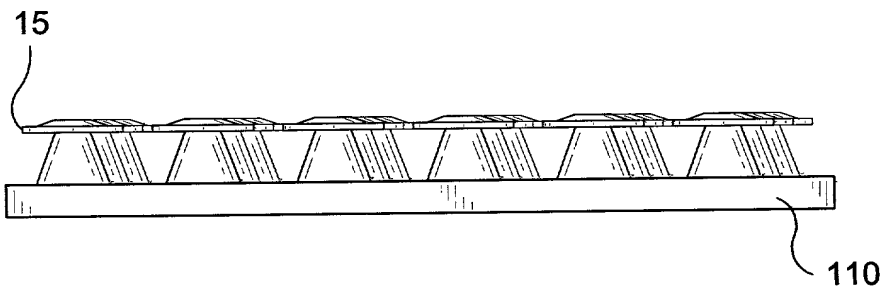


FIG-23

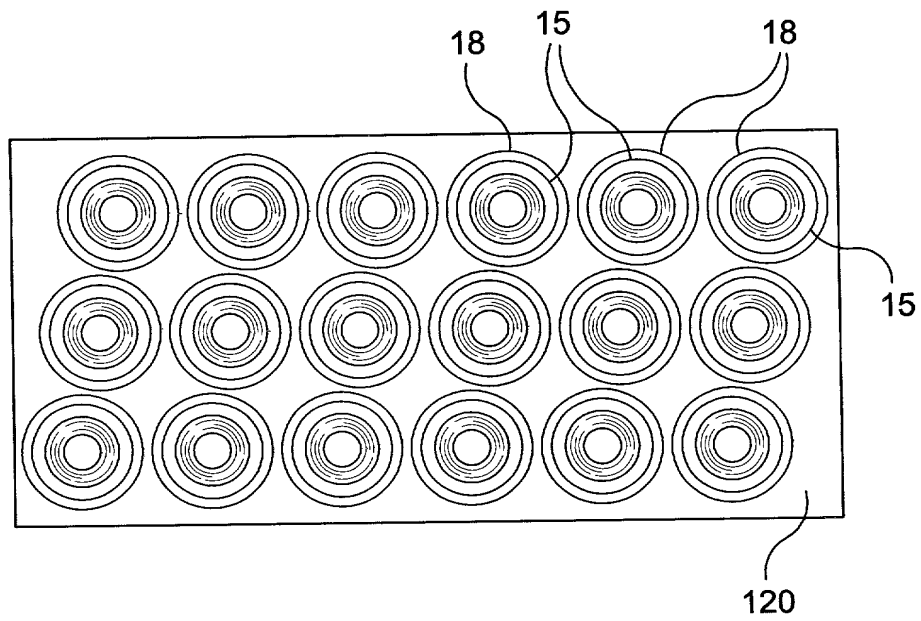


FIG-24

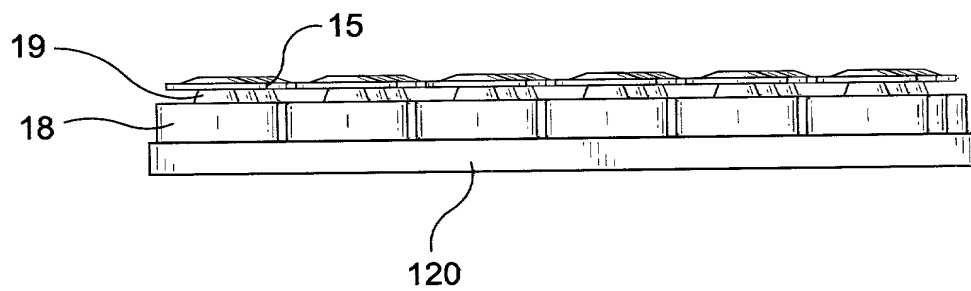


FIG-25

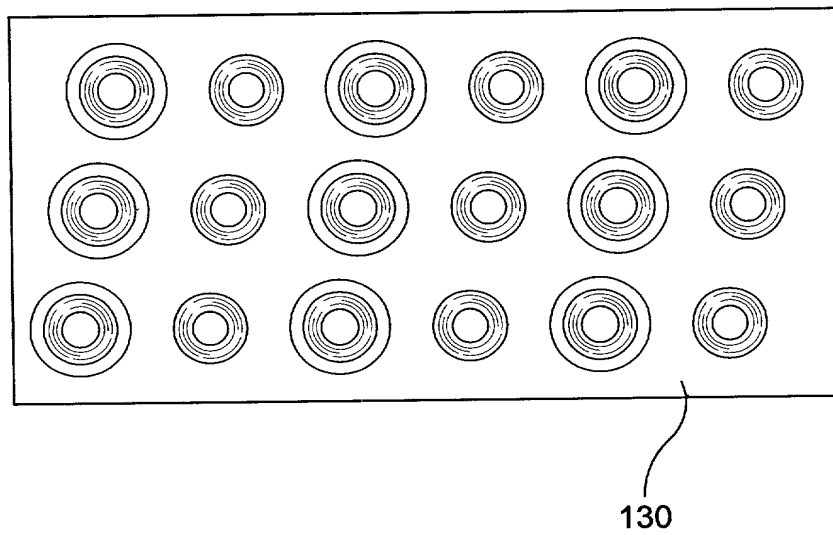


FIG-26

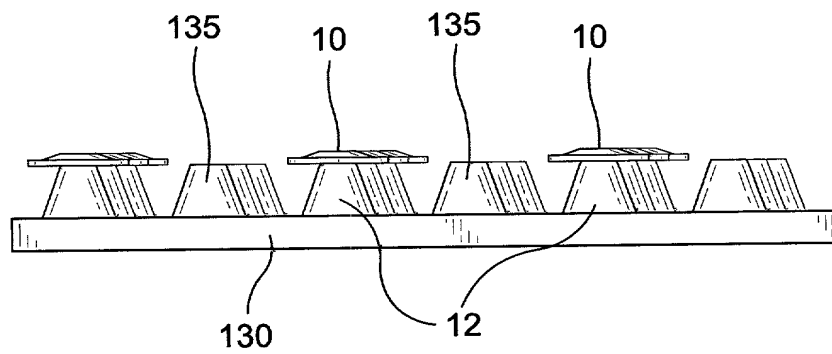




FIG-27

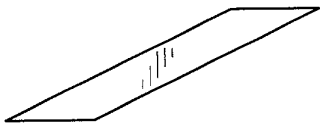


FIG-28

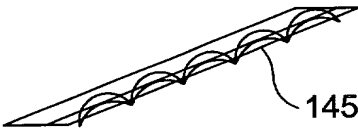


FIG-29

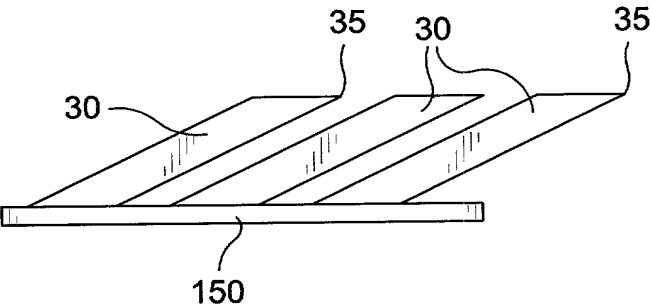
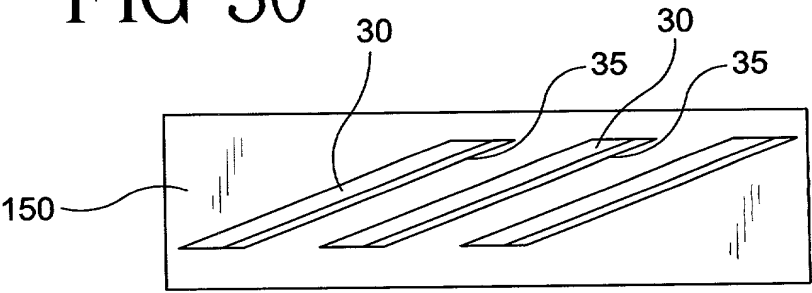


FIG-30



008240" E6T92960

FIG-31

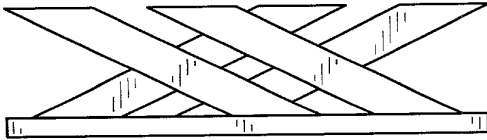


FIG-32

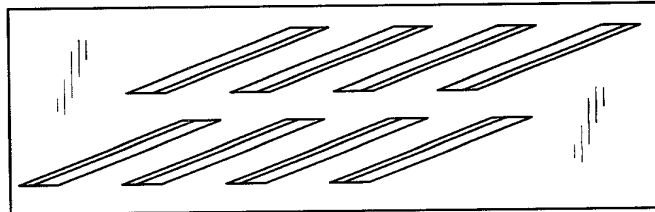




FIG-35

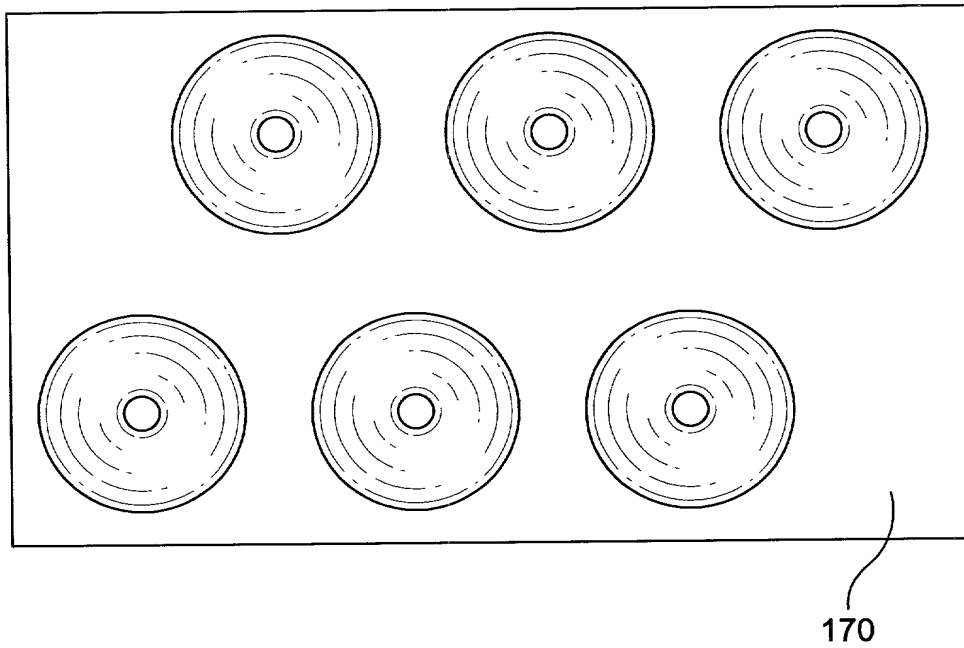


FIG-36

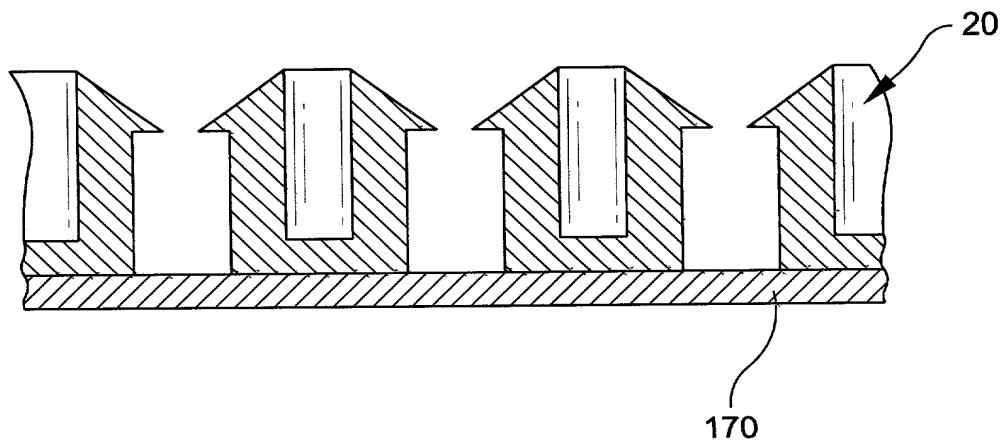


FIG-37

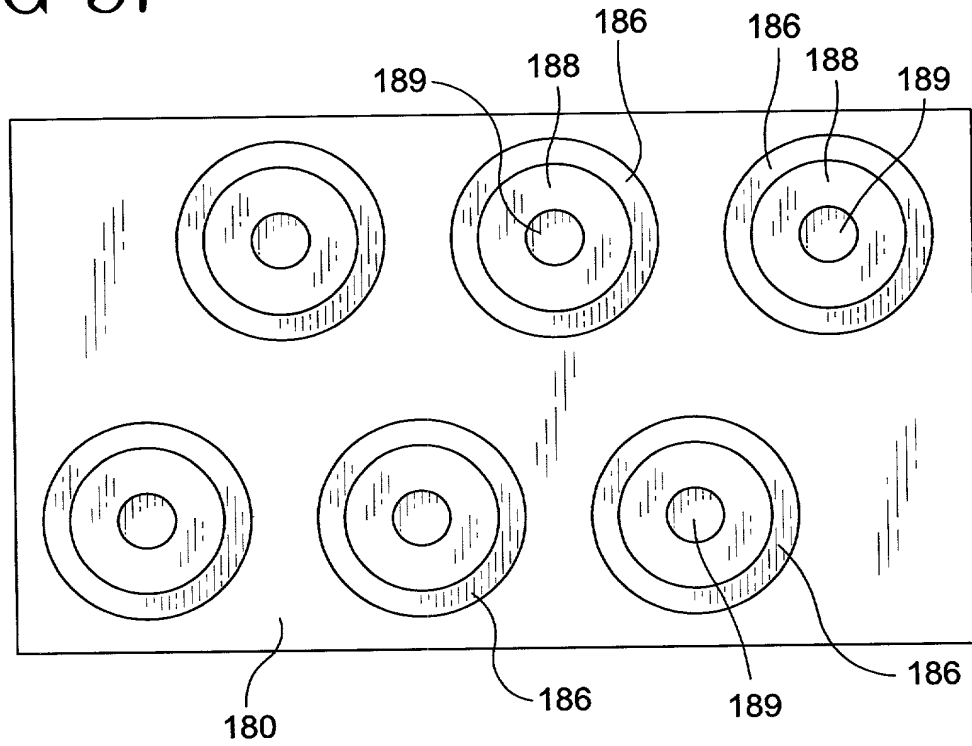


FIG-38

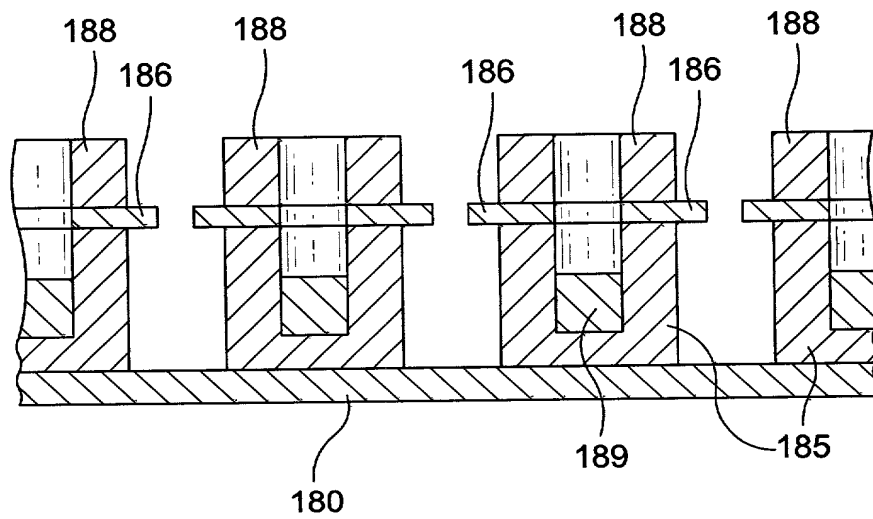


FIG-39

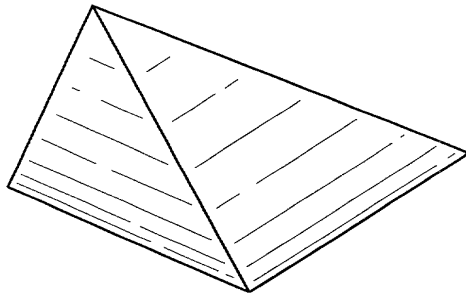


FIG-40

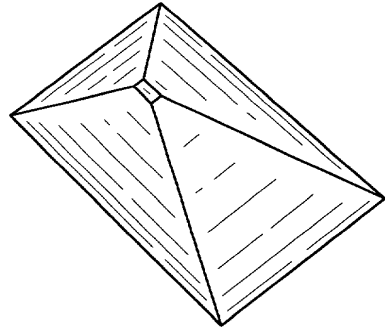


FIG-41



FIG-42

